FCC DSTAC Working Group 2

DBS Architecture Overview

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DBS Architecture Overview

I. Satellite to Home Distribution Path

II. ODUs and Interfaces to STBs

III. Whole Home HD DVRs

IV. Service Delivery to Consumer Devices

V. DBS Risks and Threats

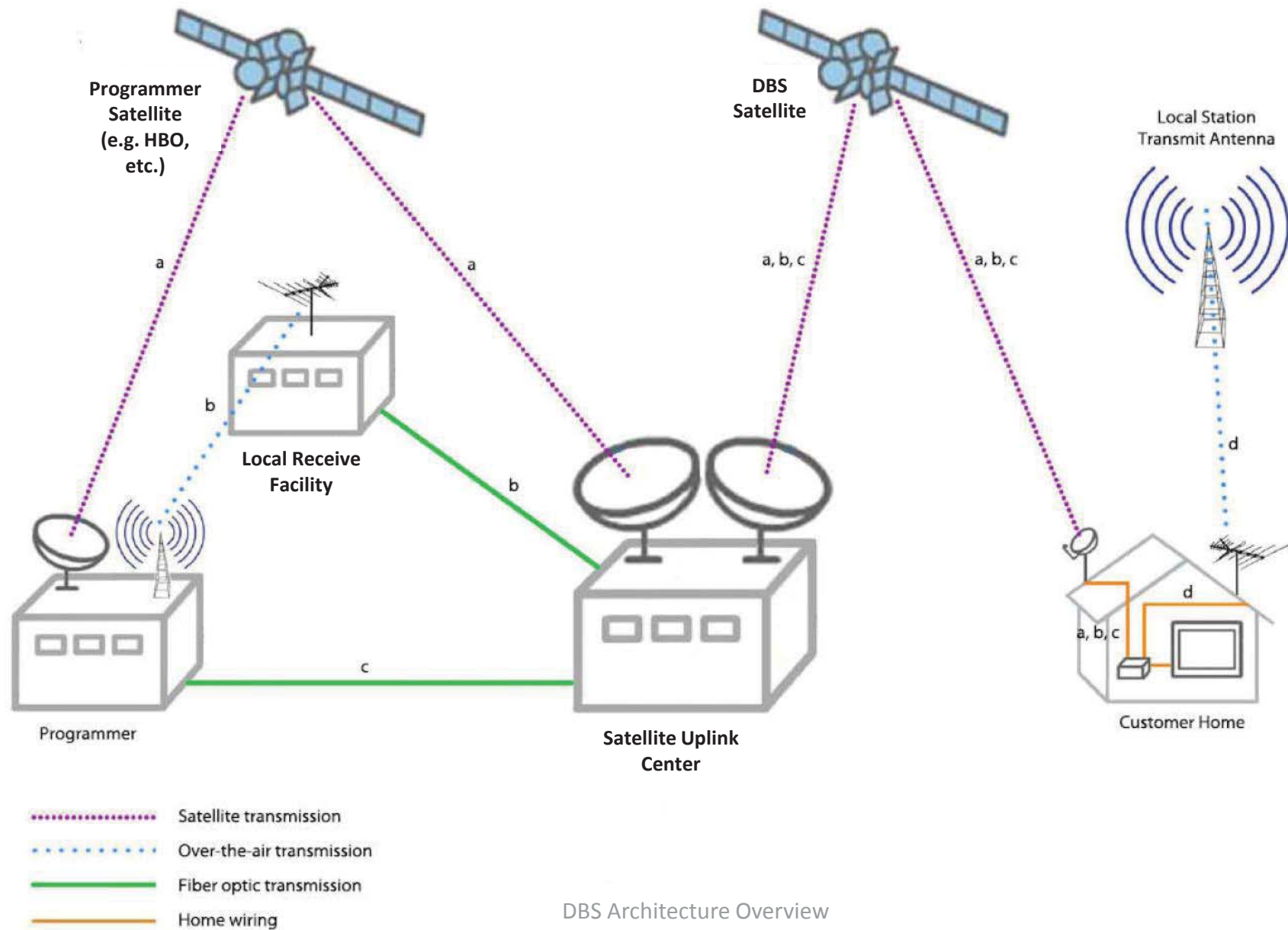VI. (Not covered: non-residential services)

I. Satellite to Home Distribution Path

- Satellites & orbital positions
- Satellite frequencies
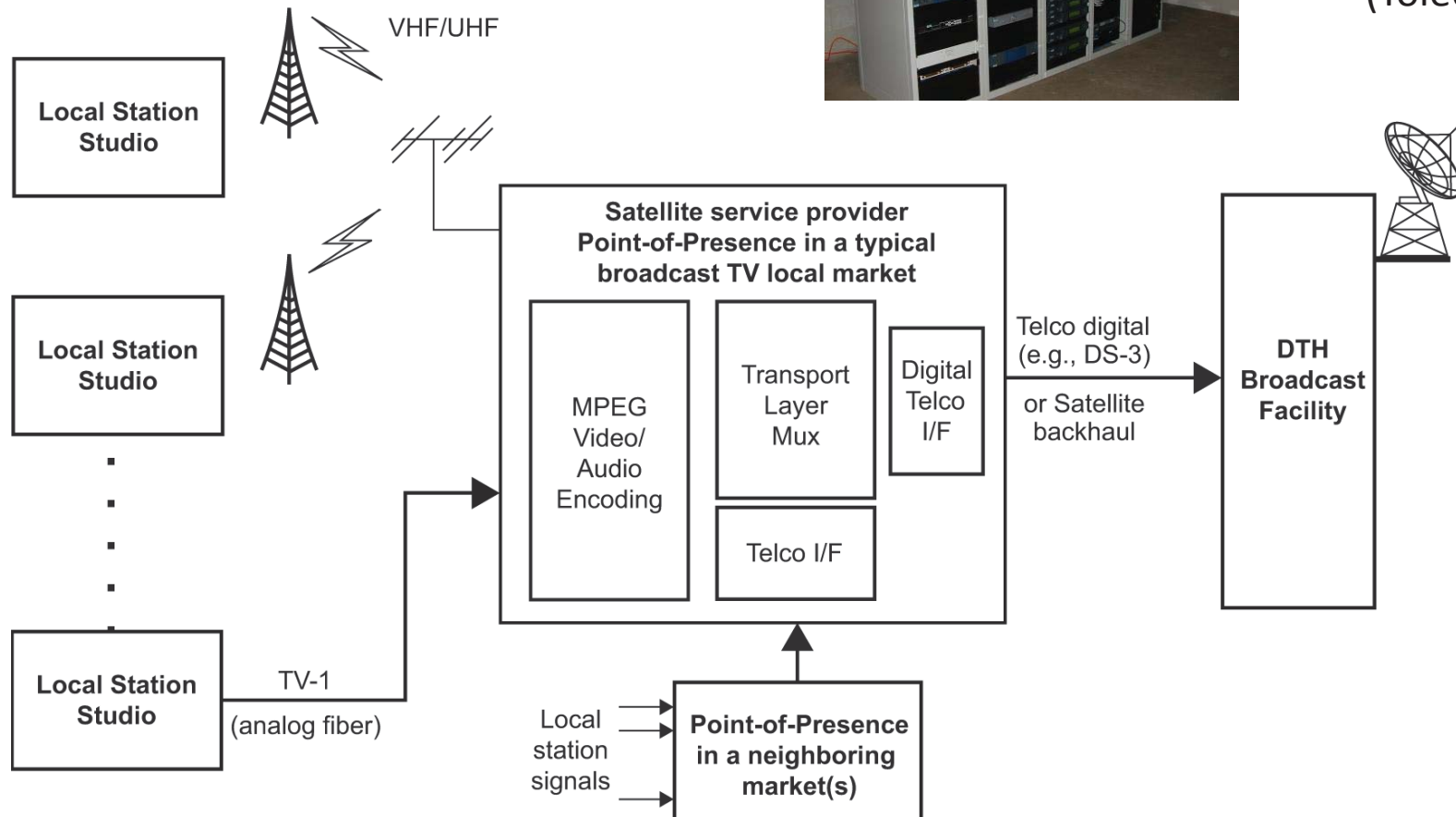- Local Collection Facilities
- Broadcast Centers

DISH Broadcast Center(Cheyenne, WY)
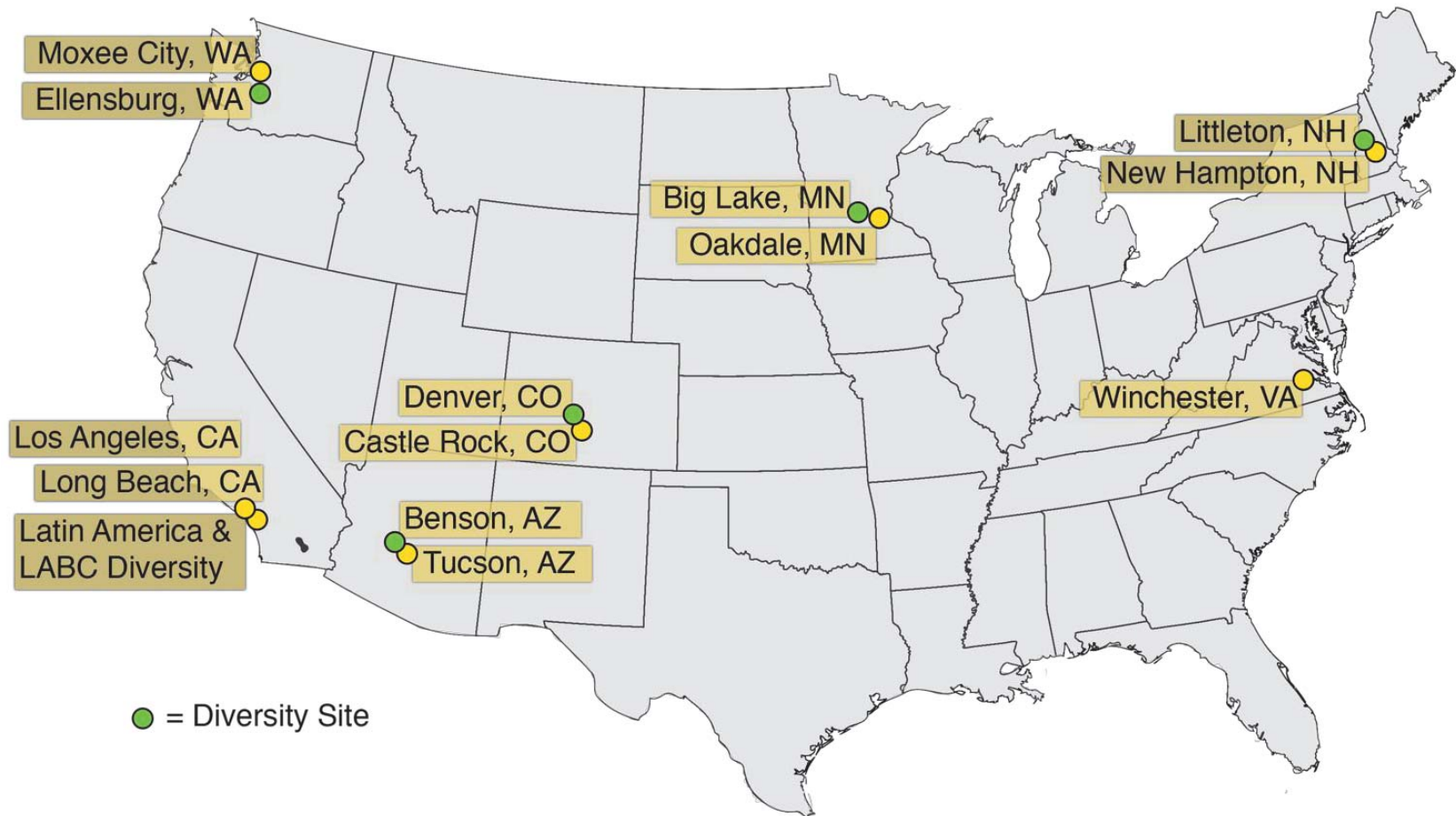
Satellite to Home Distribution Path

Programmer Satellite (e.g. HBO, etc.)

DBS Satellite

Local Station Transmit Antenna

a

a

a, b, c

a, b, c

Local Receive Facility

b

b

c

d

Programmer

a, b, c

d

Customer Home

Satellite Uplink Center

················· Satellite transmission

· · · · · · · Over-the-air transmission

—— Fiber optic transmission

—— Home wiring

Local Collection Facilities (LCFs)

DIRECTV Local Collection Facility (Toledo, OH)

DIRECTV Uplink Facilities

- Local uplinks to spot beam satellites
- Ka band requires "diverse" facilities

Moxee City, WA
Ellensburg, WA
Littleton, NH
New Hampton, NH
Big Lake, MN
Oakdale, MN
Denver, CO
Castle Rock, CO
Los Angeles, CA
Long Beach, CA
Latin America &
LABC Diversity
Benson, AZ
Tucson, AZ
Winchester, VA

● = Diversity Site

DISH Uplink Facilities (provided by EchoStar)

- Local uplinks to spot beam satellites via Gateway Facilities

★ Primary EchoStar Gateway Facility
● EchoStar Gateway Facility
● EchoStar Fiber Point of Presence
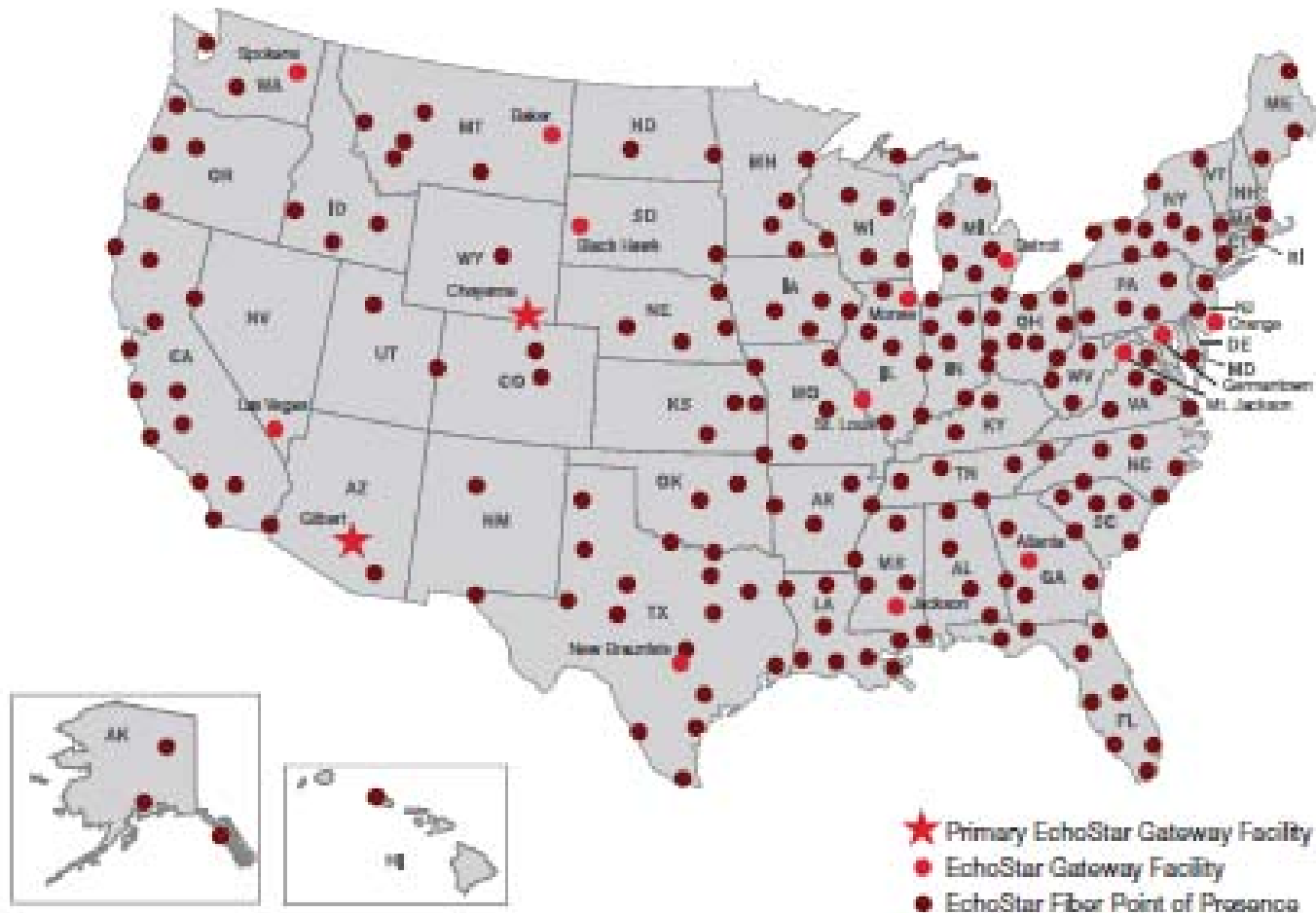
Dozens of Satellites

D-14 Satellite Launch on Ariane 5

4 Dec 2014 D-14
12:38pm Pacific / 4:50pm Eastern

- ## Orbital Positions Differ
  - DIRECTV: 99W, 101W, 103W as well as 110W, 119W & 95W
  - DISH: Eastern US Arc – 61.5W, 72.7W, 77W,
    Western US Arc – 110W, 119W, 129W and shared 118.7W
- ## Satellite Frequencies Differ
  - DIRECTV: Ku BSS - SD, Ka FSS - HD services, Ku FSS - some international channels
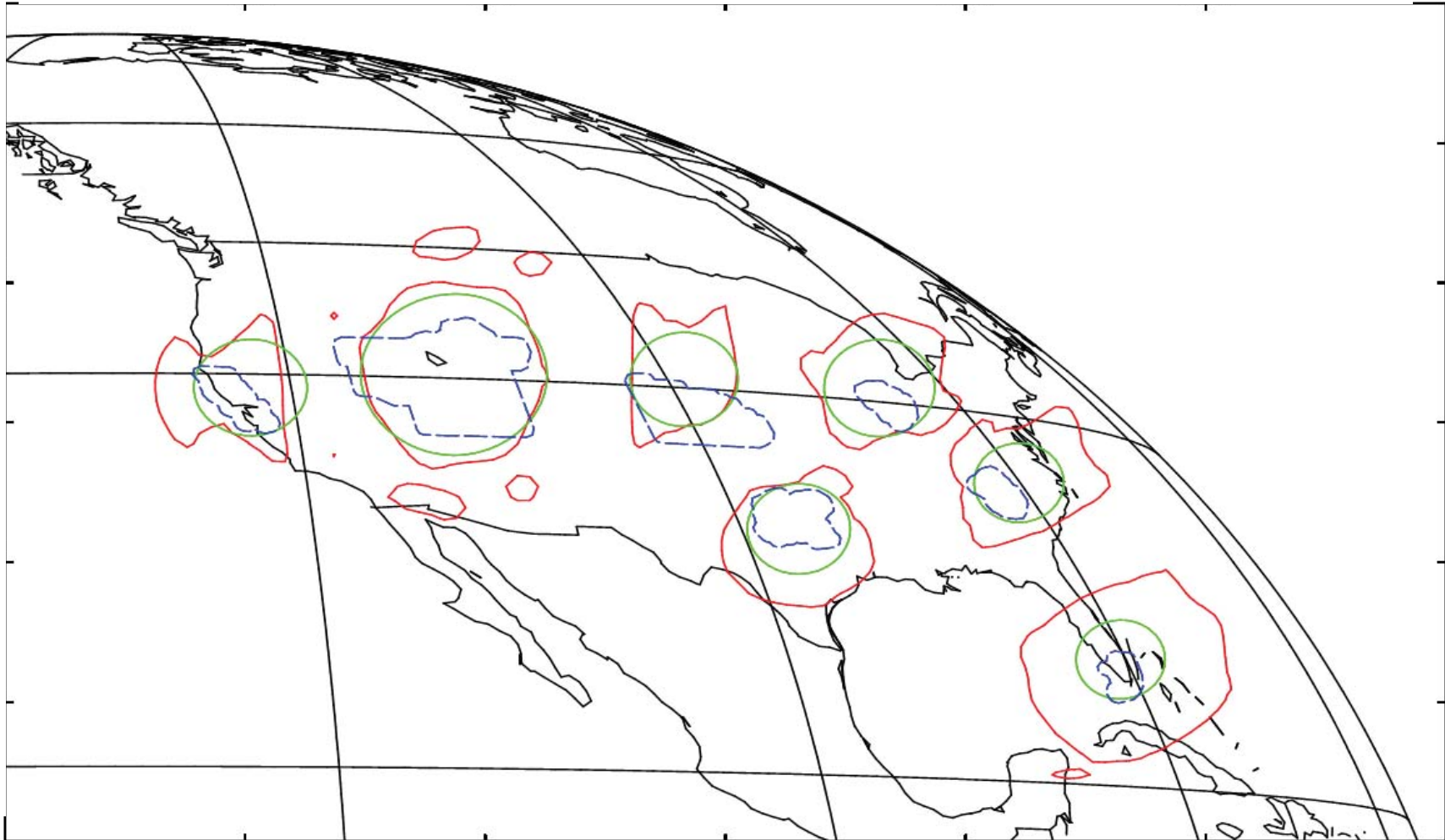 - DISH: Ku BSS -SD/HD services , Ku FSS – international channels

National Beams and Spot Beams

CONUS – Transponder covers Continental US including AK and HI
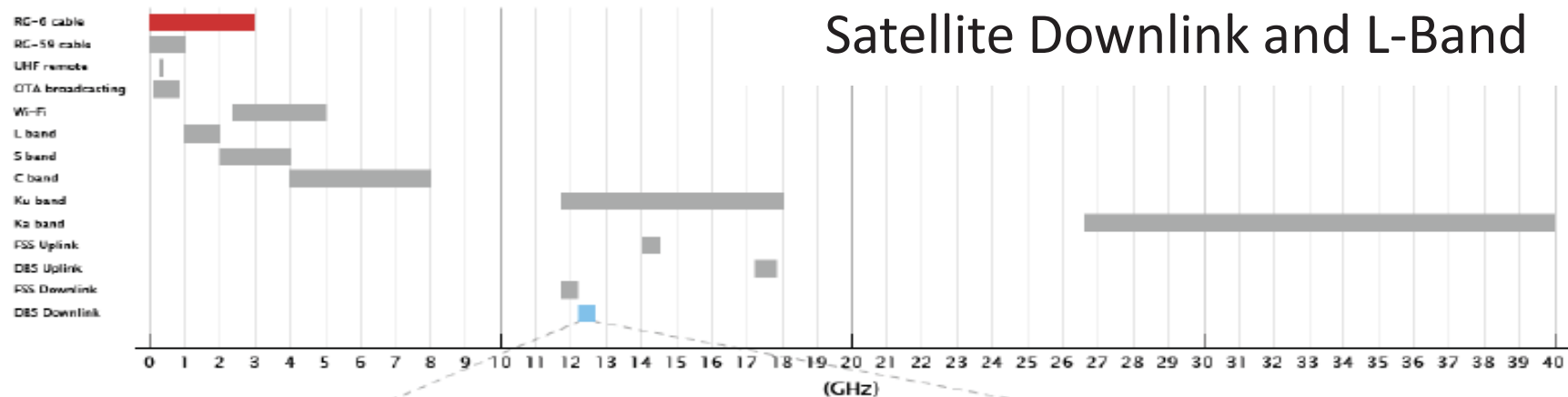Spot Beams – Allows reuse of downlink frequencies for local channels

DISH Frequency Plans
Satellite Downlink and L-Band
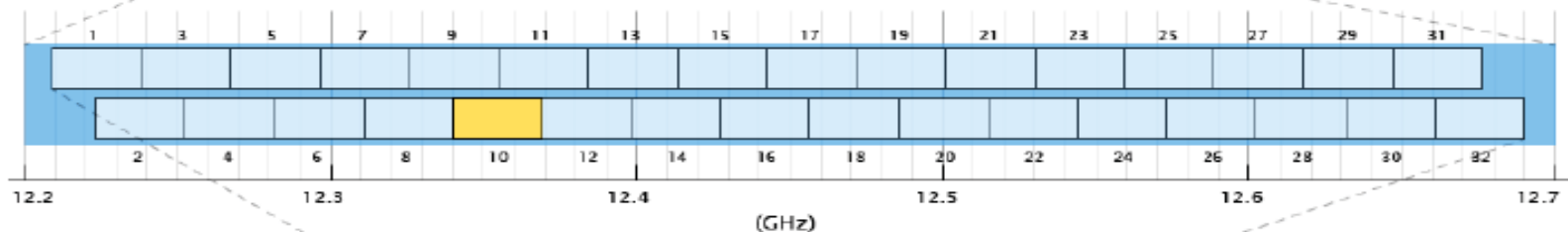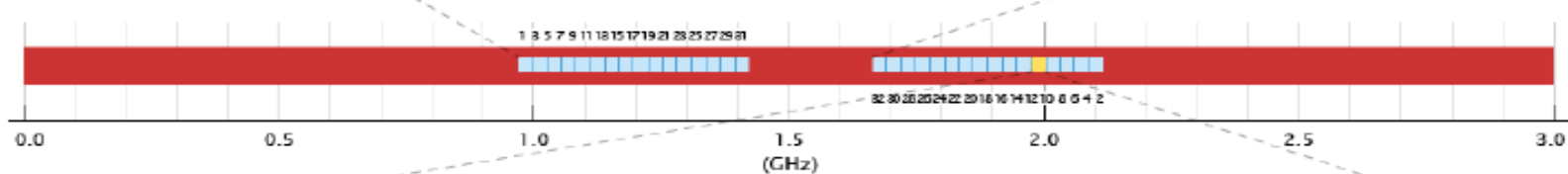
DIRECTV Frequency Plans
Satellite Downlink and L-Band

- ## Satellite RF Downlink

500 MHz		500 MHz	500 MHz
500 MHz		500 MHz	500 MHz

12.2 GHz — 12.7 GHz   18.3 GHz — 18.8 GHz   19.7 GHz — 20.2 GHz

Ku-Band   **Ka-"B" Band**   **Ka-"A" Band**

11.25 GHz Down-conversion

18.05 GHz Down-conversion

18.05 GHz Down-conversion
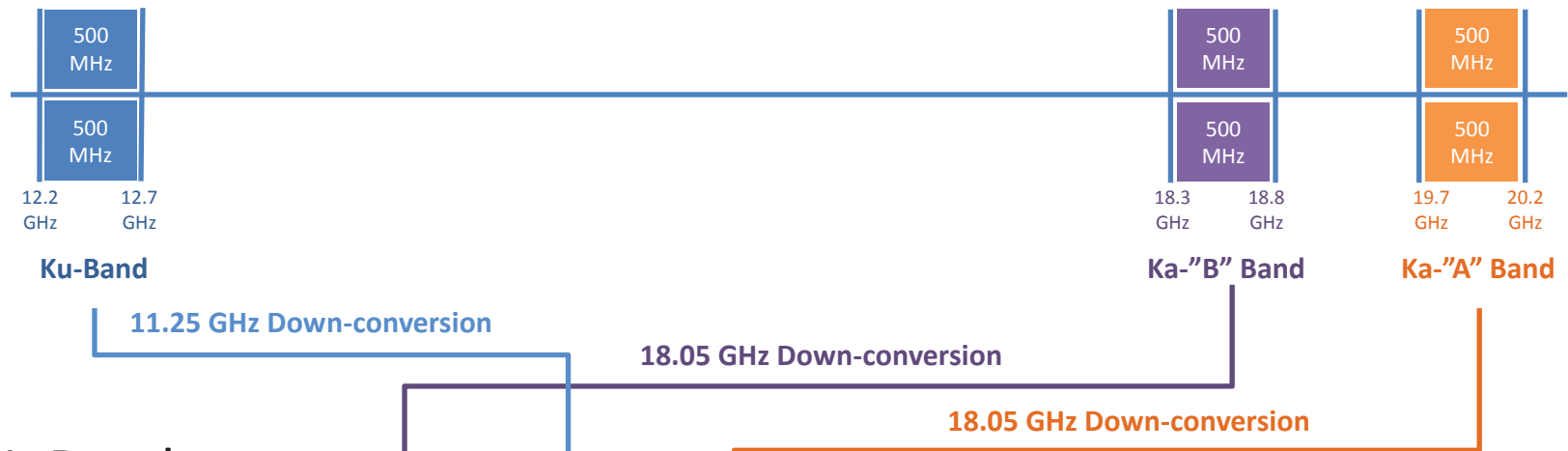
- ## LNB L-Band Frequency Plan

500 MHz	500 MHz	500 MHz
500 MHz	500 MHz	500 MHz

250 MHz — 750 MHz   950 MHz — 1450 MHz   1650 MHz — 2150 MHz

Ka-"B" Band   **Ku-Band**   **Ka-"A" Band**
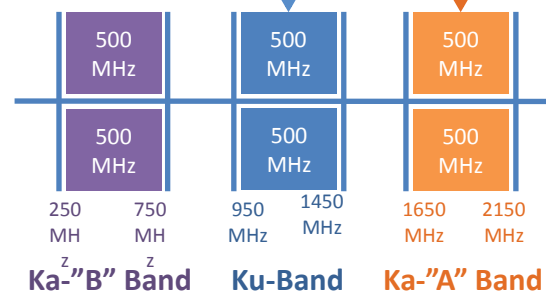
- Ku-Band is used for Standard Definition programming
- Ka-Band is used for High Definition programming

II. ODUs & Interfaces to STBs

- ODUs and LNBs
- Frequency Plans
- Multiswitch
- Multiswitch control

Current DIRECTV ODUs

- 18" Round (SD only)

- 18x20" Triple-Sat (SD only)

- Slimline ODU (HD)
  - used with Slimline-3 or Slimline-5 LNB

- International World Direct

ODUs & LNBs

- Powered from:
  - DISH - All STBs in home
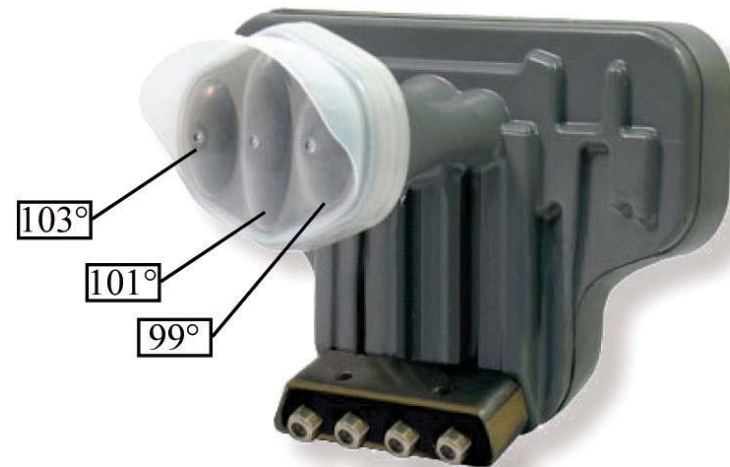 - DTV - Dedicated EPS
- DTV – SWM3 and SWM5
  - 4 STB feeds
- DISH – 1000.2 and 1000.4
  - 3 STB feeds

3 Orbitals to 3 Receivers

103°
101°
99°
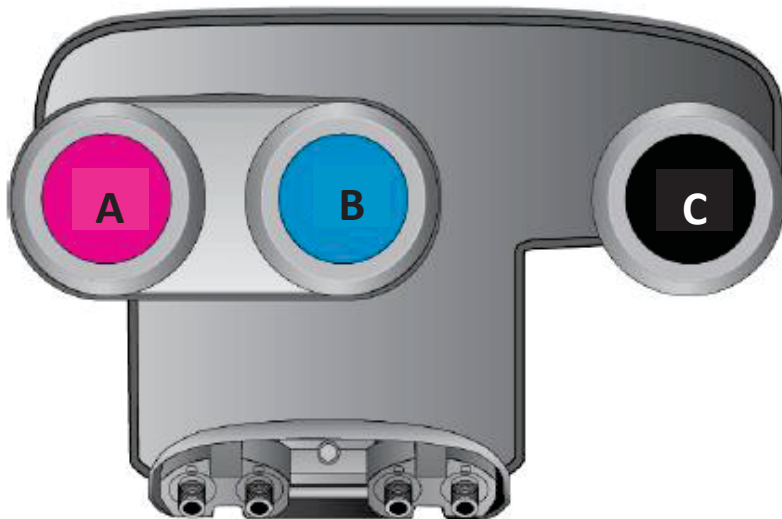
DISH 1000.4

DIRECTV SWM3

Multiswitch (DISH)
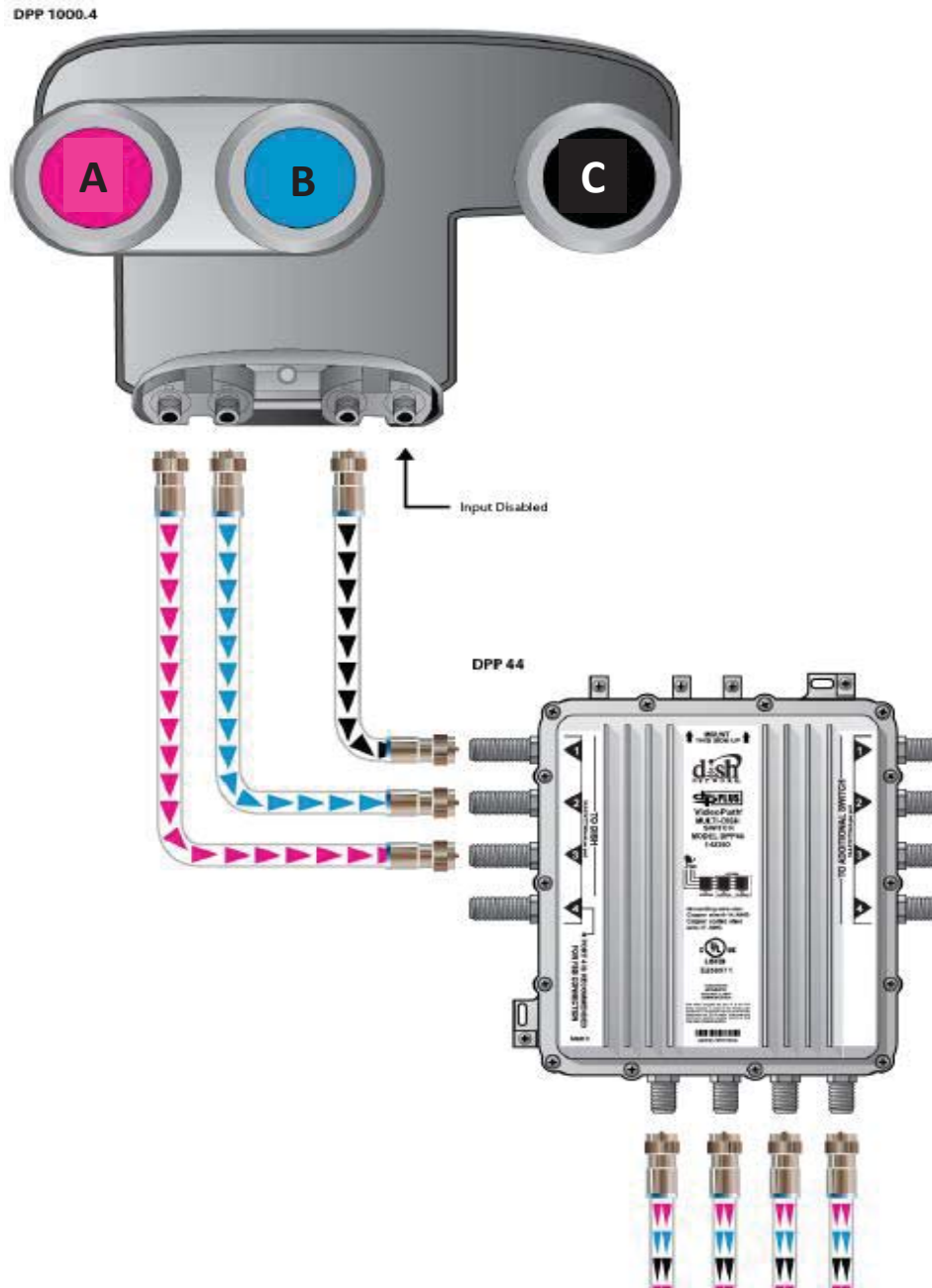
Multiswitch (DIRECTV)

Zinwell 3x4 Multiswitch

PBI 3x4 Multiswitch

Zinwell 6x8 Multiswitch

Zinwell 8-Channel SWiM Module

Zinwell 16-Channel SWiM Module

Zinwell 32-Channel SWiM Module

Multiswitch Control

- Allows a receiver to select between multiple input signals to expand the available bandwidth into the home

18x20" Triplesat ODU — 950–1450 MHz →

101° RHCP
101° LHCP
119° RHCP
110/119° RHCP

Multi-switch

950–1450 MHz →

1. IRD sends voltage and tone to select desired input
2. Multiswitch switches desired signal to the coax cable where request came from

Integrated Receiver Decoder (IRD)
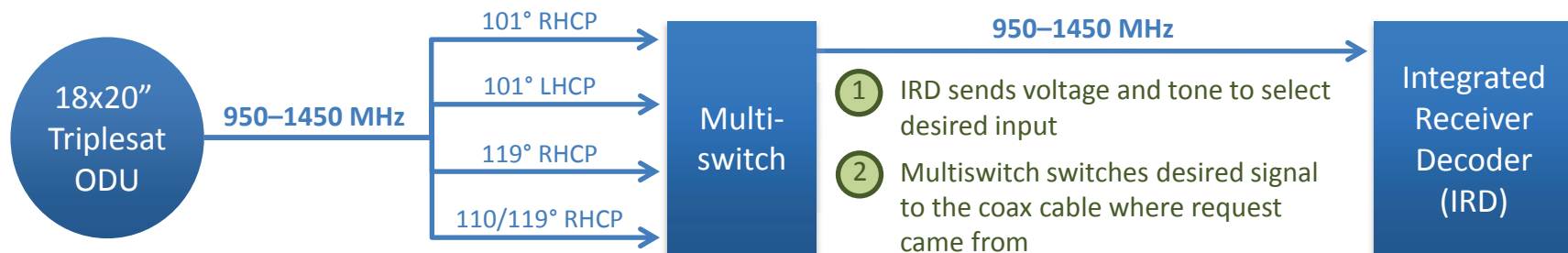
DIRECTV Example: SD

Multiswitch Control, cont.

- DIRECTV uses a Pulse-Width Modulated (PWM) control scheme
  - Simple 3-byte messages identify desired input port
  - Does not strictly conform to the DiSEqC standard
- DISH uses system based on and conforming to DiSEqC but extending the standard with additional commands
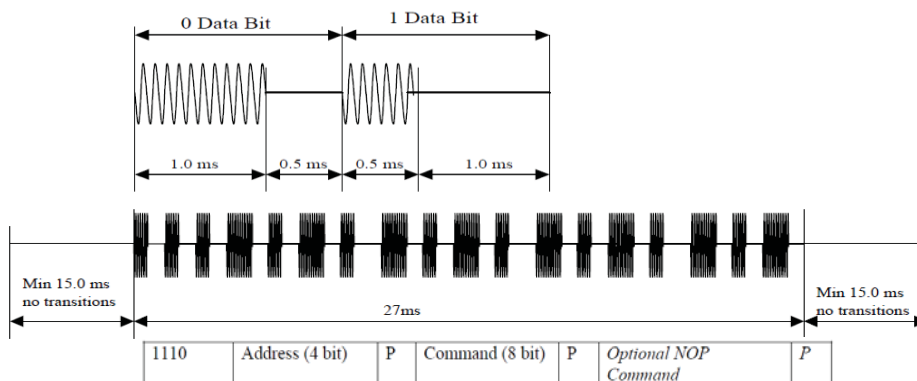
code	address
0x0	Any Device
0x1	Multiswitch
0x2	BBC

code	command
0x00	NOP
0x01	Reset
0x02	INP 1
0x03	INP 2
0x04	INP 3
0x05	INP 4

Single Wire Multi-Switch (HD)

- Allows multiple, independent tuners to share a single coaxial cable
  - Rather than switch the whole input into the cable to the IRD, a specific transponder is filtered out and frequency-shifted for each tuner
  - The filtered and shifted transponders are combined and amplified, and then sent down the coax cable
  - Frequency Shift-Key (FSK) modulation is used to send commands from IRD to SWM

974.00	1076.06	1178.12	1280.18	1382.24	1484.30	1586.36	1688.42	1790.48
SWiM Channel 1	SWiM Channel 2	SWiM Channel 3	SWiM Channel 4	SWiM Channel 5	SWiM Channel 6	SWiM Channel 7	SWiM Channel 8	SWiM Channel 9
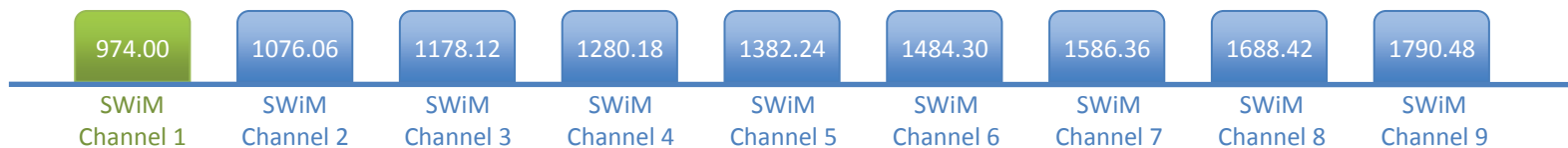
III. Whole Home HD DVRs

- Server-Client Architecture
  - MoCA IP networking
  - Hybrid Satellite-Broadband Model
- RVU
  - 4K delivery
- Include smartcard chip on device motherboard

Server-Client Architecture (DIRECTV)

SWiM

MoCA & SWM
Home Network

Master Bedroom

Genie Mini
Wireless RVU Client

Kid's Room

Genie Mini
RVU Client

Office / Den

GenieGo

Router

Internet

Wireless
Video Bridge

Genie Server

Family Room

RVU TV
(DIRECTV Ready)

Kitchen

Server-Client Architecture (DISH)

Solo Node – Triple Stacks 3 500 MHz Satellite Bands

Splitter

MoCA / RG 6 or 59

RG6

dp PLUS
XIP SOLO NODE
190834

TO THIN CLIENT (MoCA) DC blocked

18.5-21V
756mA per port
TO ODU

TO LNBFs
TO RECEIVER
TO THIN CLIENT

TO RECEIVER SATELLITE IN 18.5-20V

Grounding wire size: Copper wire-8-14 AWG
Copper coated steel wire-17 AWG

MMTTVV-FMYYXXXXX

MoCA / RG 6 or 59

MoCA / RG 6 or 59

MoCA / RG 6 or 59

Satellite In / MoCA

RG6

Hopper

Joey 1   Joey 2   Joey 3

Server-Client Architecture

Server

- ## Satellite Input
  - Transport Layer – MPEG (DISH, DIRECTV HD), "DSS" (DIRECTV SD)
  - Conditional Access Systems – DIRECTV (NDS) and DISH (Nagra)
  - Live Linear and File-based VOD content delivery

- ## IP Input (if available)
  - VOD content (over customer's Broadband Internet Service)
  - DIRECTV: Adaptive Bit Rate Streams using NDS CAS / NDS DRM
  - DISH: Adaptive Bit Rate Streams using Nagra DRM

- ## Output
  - Analog (Component and Composite) and HDMI (HDCP) Video
  - MoCA/Ethernet/WiFi - IP Home Network (DTCP-IP) to Clients

- ## One HDD serves whole home
  - Trick play buffer for all clients
  - File based VOD and DAI MVPD-controlled content storage
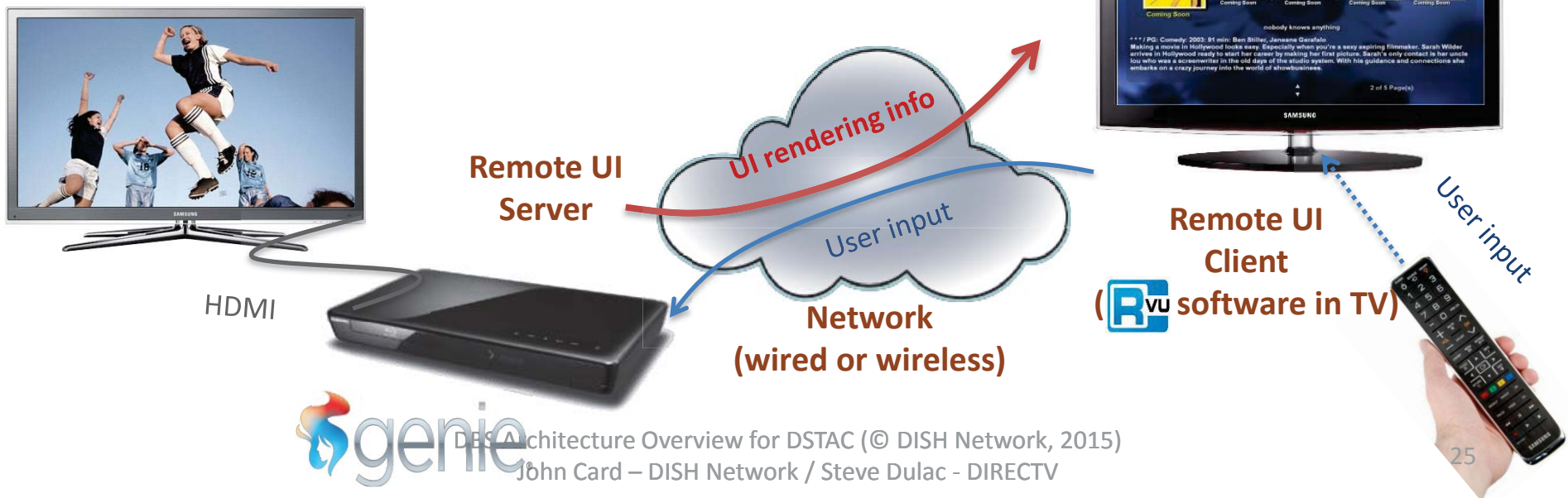 - Customer DVR content storage

Server-Client Architecture

Client

- ## No Satellite Input
  - Allows client functionality to be integrated into connected televisions

- ## IP Input
  - MoCA/Ethernet/WiFi - IP Home Network (DTCP-IP) from Server

- ## Output
  - Analog (Component and Composite) and HDMI (HDCP) Video
  - No IP output from client

RVU Remote User Interface (RUI)

- Full DIRECTV experience without a STB at every TV
  - Reduces costs, saves energy
- Industry standards increase adoption by TV manufacturers (see rvualliance.org/products)
  - "DIRECTV Ready" logo allows co-marketing programs
- Since TV decodes video, can deliver new 4K services
  - Streamed from Genie

Remote UI Server

UI rendering info

User input

HDMI

Network
(wired or wireless)

Remote UI Client
(RVU software in TV)

User input

DIRECTV 4K Ultra HD VOD

- Launched Nov 2014 with titles from Paramount Pictures, K2
- First compatible TV models from Samsung, with LG, Sony, Panasonic, Sharp expected in 2015
- DTCP-IP protected streaming from Genie to TV
- 6M Genie homes are 4K ready (require no DIRECTV upgrade)

Star Trek Now playing on DIRECTV in 4K

http://www.directv.com/technology/4k

IV. Service Delivery to Consumer Devices

- BYOD (Bring Your Own Device)
  - Smart phones
  - Tablets
  - PCs / Laptops
- Access content both in-home & out-of-home
  - From your DVR
  - From the cloud
- Use of geolocation technologies is a commonplace content owner requirement
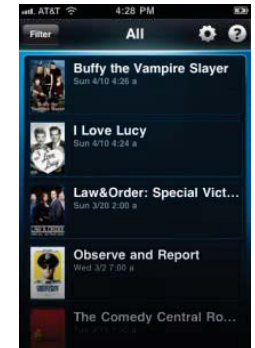
Service Delivery to Consumer Devices

- **Whole Home DVR to Mobile Device Apps**
  - **DISH (Nagra)**
    - **Server embedded Sling HW - DVR + Live Linear content, some VOD**
    - **Sling = Real-time transcoding to match available network capacity**
  - **DIRECTV (NDS VideoGuard Connect)**
    - **GenieGo device transcodes DVR content (e.g. for sync-and-go)**
- **Whole Home DVR to Smart TVs over MoCA, Ethernet or WiFi**
  - **DISH (DTCP-IP)**
    - **DISH Smart TV Apps**
  - **DIRECTV (DTCP-IP)**
    - **RVU connected televisions, aka "DIRECTV Ready"**
- **Browser access using Adaptive Bit Rate Streams**
  - **DISH (Nagra)**
    - **DISH Anywhere (www.dishanywhere.com)**
  - **DIRECTV (NDS VideoGuard Connect, with a few exceptions)**
    - **DIRECTV Everywhere (www.directv.com/technology/directv_everywhere)**

DISH Output Protection Use Case

- Before the late 2000's, DISH's commercial requirement to enable HDCP on appropriate outputs was "Enable HDCP on all channels if and only if the display (TV) supports HDCP."
- In the late 2000's, in response to contract terms negotiated with multiple content providers, DISH added a commercial requirement: "For certain signaled channels, do not output the channel over DVI/HDMI unless HDCP support is enabled."
- This capability was applied first to PPV channels, and then to a set of subscription channels, and then to some cable channels.
- Based on an overall requirement to control costs of CSR interactions, dependent requirements were developed to communicate with the customer when they tried to tune a non-HDCP enabled display to such a channel.
- This capability is a current commercial requirement.
- This capability is not applied to all DISH channels.

V. DBS Risks & Threats

- Terminology
- Relevant Business Processes
- Example Threats and Features
  - Smartcard emulators
  - Pirate STB
  - Unplug to miss EMM
  - Callback control
  - Moving receiver out of market or country
  - Control word sharing
  - Account packing/Mirroring fraud
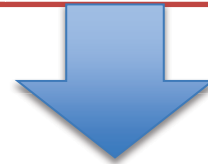 - Complete system failure

Terminology

- **Entitlements**
  - State managed by CAS that is interpreted by decryption engine or other parts of the receiver to mean "is action <X> authorized", where action may be "receive video", "show channels on controlled list", "enable receiver feature <Y>", etc.

- **Receiver CAS variables**
  - Other persistent data on smartcard managed by CAS such as credit authorization limit, PPV purchase records, physical receiver address, etc.

- **Entitlement Management Message (EMM)**
  - Encrypted message that adds, revokes, or updates entitlements and receiver CAS variables.

- **CAID**
  - Managed unique ID that identifies particular smart card

- **Receiver ID**
  - Managed unique ID that identifies particular device hardware

- **OSD (on screen display)**
  - CAS generated message to aid with customer service

Relevant Business Processes

- STB Installation Process
  - Includes a step where installer provides CAID and Receiver ID, and CAS system broadcasts series of EMMs that
    - Cryptographically pairs the smartcard and receiver
    - Adds initial entitlements to smartcard
    - Appear on all possibly tuned transponders (DISH, DIRECTV SD) or on a specific transponder (DIRECTV HD, these STBs have a dedicated "network tuner")

- STB Deauthorization and Equipment Return
  - Includes steps that
    - Remove personal information from receiver and smartcard
    - Dumps PPV records from smartcard for final bill

Threat Spectrum

DBS Historical Experience!!!

| University Student with $100 budget | Hacker club of surly engineers | Organized criminal gang | NSA |

Smartcard emulators

- Devices that electrically mimic authorized smartcards to an actual receiver

- Selected mitigation methods
  - Audits of authorized receiver id's
  - Smartcard built into receiver
  - Encrypted communication between smartcard and receiver
  - Physical smartcard design trade secrets

Pirate STB

- Commercially produced, unauthorized receiver devices or receiver software or hardware add-ons sold to knowing or unknowing "customers".

- Selected mitigation methods
  - Strong pairing of known devices with known smartcards
  - Receivers run only signed code
  - Coordination with US Customs and FCC

Unplug to miss EMM

- Customer subscribes to many channels, then disconnects receiver, then cancels all but basic service. Customer waits <a while> to reconnect.

- Selected mitigation methods
  - Entitlements expire over time and need to be renewed.
  - CAS system sends update messages automatically
    - Increased message traffic on broadcast system

Callback control

- Customer orders PPV or VOD up to credit limit stored on smartcard. Customer never connects receiver to backchannel to submit/clear purchases.
- Selected mitigation methods
  - Dump PPV records on equipment return
    - Chargebacks for unreturned equipment
  - Managed credit limits that increase after creditworthy behavior
  - Free PPV certificates
  - Receiver UI interactions with customer

Dishonorable Mentions

- Moving receiver out of market or country
  - Customer subscribes to US service and installs receiver elsewhere but under beam.
- Control word sharing
  - Centralized server decrypts broadcast keys and distributes in near-real-time to "customers".
- Account packing/Mirroring fraud
  - One customer authorizes multiple receivers for multiple households
- Selected mitigation methods
  - Data mining techniques
  - Affirmative customer contacts

Total System Failure

- Each DBS provider has renewed their respective CAS systems including replacing smartcards in the field at least once.

- Ongoing evolution of the CAS systems mean new smartcard generations and other updates are continually deployed.

- We each rely on technologies from our respective CA vendors that we don't know about.

VI. Sir Not-Appearing-In-This-Overview

- Both providers have non-residential customers that may use receivers designed to specific environments.
  - Restaurants
  - Multi-family dwellings
  - Hotels
  - Hospitals
  - Airplanes
  - Boats, RVs, cars…
- Trusted insiders.